Industrial Symbiosis to Minimize Contamination

Contaminación industrial
Segundo cuatrimestre 2007
Universidad de Valencia

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Abbreviations

SME - Small and medium sized enterprises

NUTEK - the Swedish Business Development Agency

IIIEE - the International Institute for Industrial Environment Economics at Lund University

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1. Introduction

Since 1970, the industrial areas have increased in number and play an important role in the economical development of many countries in the world. The industrial parks have been counted to more than 12 000 and the amount is every year growing. These industrial areas should not only be regarded in relation to the production of goods and services, but also for the significant impact they create on the surrounding environment. The generation of waste, the level of contamination, and the security conditions may vary a lot between areas depending on if it is a small commercial plant or a heavy industry. Hence, an accumulation of industries offers possibilities to synergize in a way that might be impossible for scattered ones where each company has to work individually (Fundación Entorno). Industrial Symbiosis is a practice where, by-products, waste, energy and water from one company's operations are used as inputs for one or more partner companies. In this process the collective ecological footprint of the companies involved is reduced (Kuru et al 2005).

Collaborative synergistic connections have the potential to improve resource use efficiencies, which have been proven by operational examples of Industrial Symbiosis networks, for example those in Kalundborg, Denmark; in Ecopark Hartberg, Austria; in Ecopark Alsace, France; in Jyväskylä, Finland and in Landskrona, Sweden (Fundación Entorno; Mirata 2005). In these industrial areas great quantities of resources implanted in waste or by-product streams, which would have been wasted otherwise, are being revalorised providing both environmental and economic gains (Mirata 2005).

1.1 Background

The application of environmental programmes in industrial parks is a quite new concept (Fundación Entorno) but there is a lot of investigation in operation concerning the environmental sustainability of current industrial systems (Mirata & Emtairah 2004). The quantitative and qualitative aspects of resource use, pollutants and waste generation in industrial parks are looked upon as unsustainable. There is therefore a great need to search for, identify and implement various transformations associated with the requirements of a more environmentally sustainable development (Mirata & Emtairah 2004; Mirata 2005). Consequently, researchers from IIIEE at Lund University have consulted various public and private sector parties which led to the initiation of the first Industrial Symbiosis programme in Sweden, the Landskrona Industrial Symbiosis Programme.

1.2 Purpose and questions

This paper aims to describe the theory of Industrial Symbiosis, and to give a practical example of how this academic concept has been put into practise to minimize the contaminating impact of the industrial town of Landskrona. What are the benefits from the Landskrona Industrial Symbiosis Programme? What are the barriers this kind of projects are facing?

2. Theory

2.1 Environmentally Sustainable Development

Environmental sustainability and (environmentally) Sustainable Development is a concept advocated globally today. The expression "Sustainable Development" was published by the Brundtland Commission in 1987 and it is defined as: "humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987:24). To reach Sustainable Development three dimensions; the ecological, the economical and the social, must be integrated (Söderqvist et al 2004). Sustainability is achieved where the three dimensions meet in consensus (see Figure 1). There is a definition according to R. Goodland (a senior environmental advisor to the World Bank) and H. Daly (an ecological economist and professor at Maryland University, USA) that describes environmentally Sustainable Development as "development without growth in throughput of matter and energy beyond regenerative and absorptive capacities" (Goodland & Daly 1996:1002). In reality the work in putting Sustainable Development into effect has been very different according to the methods used and the basic conditions of the actor.

Figure 1: The triple-bottom-line figure where Sustainable Development is achieved. (http://www.york.wastewatermasterplan.ca/images/sustainability.gif, 2007-08-21)

2.2 Industrial Ecology

Industrial Ecology is a rising discipline dedicated to improving the sustainability profile of industrial systems (Mirata & Emtairah 2004). Industrial Ecology is *industrial* in the way that it focuses on product design and manufacturing processes. Therefore industry is viewed as the

primary agent for environmental improvement, as it possesses the technological expertise, the management capability, and the resources necessary for successful implementation of environmentally informed design of products and processes. In the *ecological* way Industrial Ecology looks to non-human natural systems as model for industrial activity as it also focuses on examining the sources of resources used in industrial activity and sinks that absorb and detoxify the wastes discharged by society (van Beer 2006). As it is inspired by the observed dynamics of natural ecosystems, Industrial Ecology wants to contribute to the Sustainable Development through: (a) Supporting the appearance of more cyclical resource flow patterns and (b) facilitating an essential paradigm shift in the thinking concerning industry-ecology relations. To achieve these objectives Industrial Ecology promote the implementation of various tools and strategies (Mirata & Emtairah 2004). The qualitative and the quantitative transformations in resource flow dynamics targeted by Industrial Ecology are demonstrated in Figure 2.

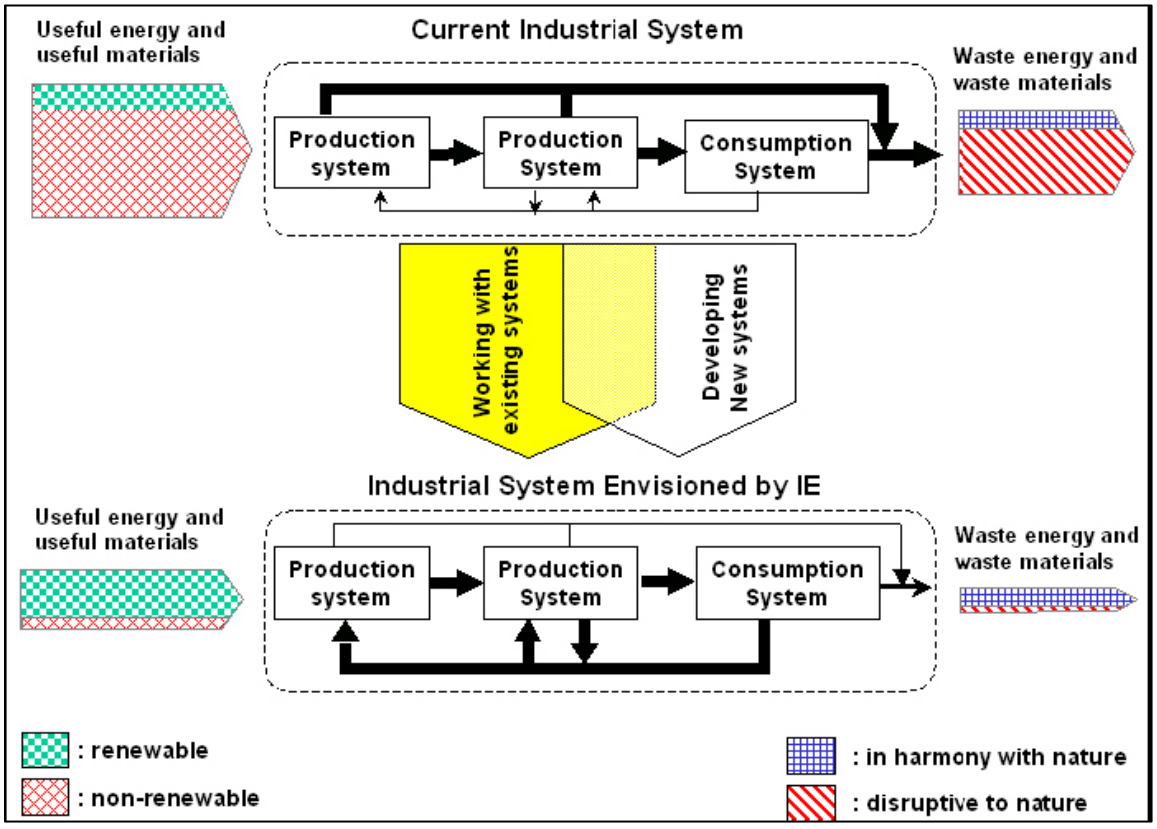

Figure 2: Resource flow related objectives of industrial ecology. (Mirata 2005)

2.3 Industrial Symbiosis

Industrial Symbiosis is probably the best-known application of Industrial Ecology principles

(van Beers 2006) and at a regional level Industrial Symbiosis networks are regarded as one of the primary means through which Industrial Ecology objectives can be met (Mirata & Emtairah 2004). Industrial Symbiosis can be defined as the synergistic exchange of material and energy between industrial organizations in a locality or region or even in a virtual community (Salmi 2006). It deals with the exchange of by-products, energy and process wastes among nearby situated companies. Because of the many links between the companies an industrial park is transformed into an *industrial ecosystem* or *Industrial Symbiosis* (van Beers 2006) and all the concepts are generally used interchangeably within studies of Industrial Ecology (van Beers 2006, Salmi 2006).

Some practices that Industrial Symbiosis can include are presented in Table 1.

Practices included in Industrial Symbiosis
Sharing of facilities and equipment
Water management including water cascading, water recycling and wastewater recovery
Capture and supply gaseous emissions as by-product (i.e. SO_2 and CO_2)
Energy management including steam recovery and reuse and cogeneration
Materials management including materials recovery and reuse
Waste management including converting waste streams to by-products and bulk-up recyclables to make collection cost-effective
Collaboration in transport, storage and logistics between companies

Table 1: Practices included in Industrial Symbiosis (after Kuru et al 2005)

2.4 The environmental impact of an industrial park

Many industries generate considerable quantities of waste and emissions which causes serious harm on the surroundings of the industrial area. Even if each industry takes their responsibility and control their own property and the environmental impact, the accumulated influence of the estate on both neighbouring and distant environment might reach unsustainable volumes (Fundación Entorno). Some examples of environmental impacts of an industrial park are illustrated in Figure 3. Beside the direct impact, i.e. contamination from emissions and waste on air, running water and soil, the scenery and future use of the area are influenced.

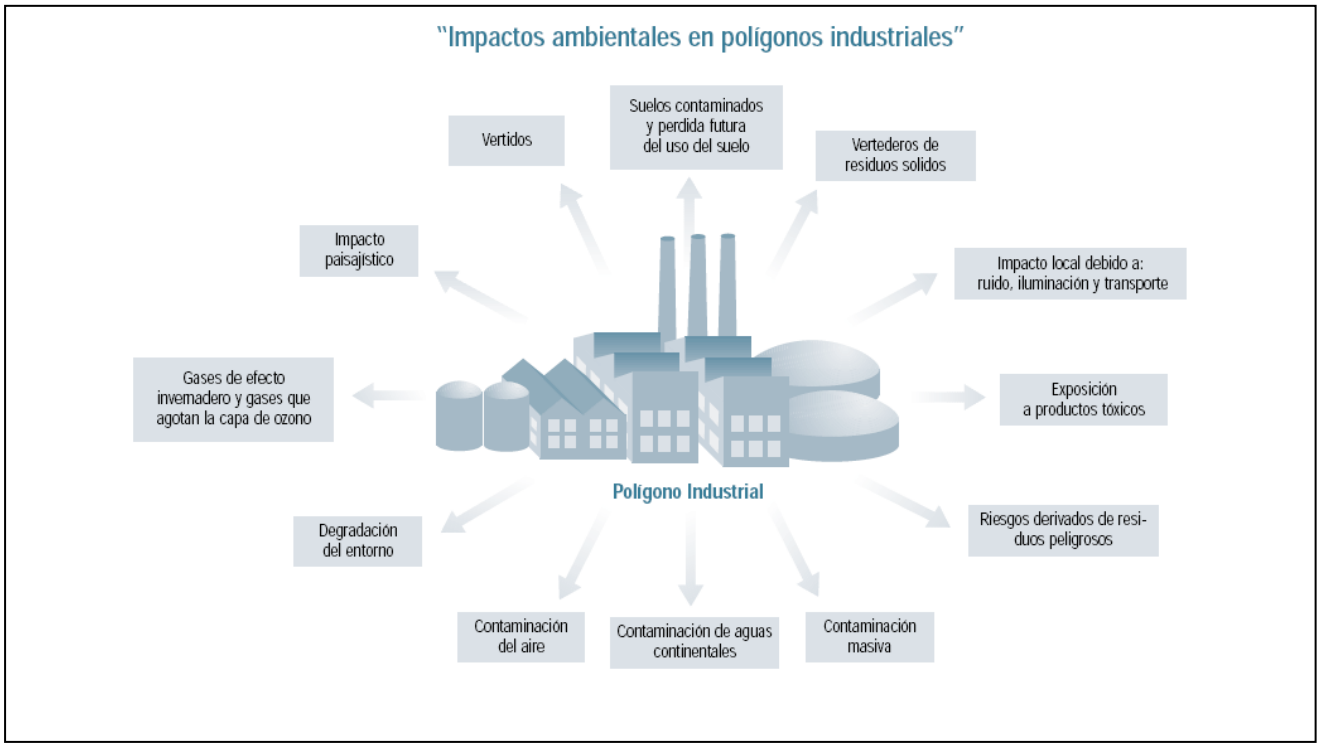

Figure 3: The environmental impact of an industrial park (Fundación Entorno)

3. The case study

The first Industrial Symbiosis programme in Sweden was started in spring 2002 around the town of Landskrona in southern Sweden (see Figure 4). The city of Landskrona has 38,000 inhabitants and a heavy concentration of industrial activities, and is surrounded by the larger cities of Malmö, Helsingborg and Copenhagen. The environmental profile of Landskrona has improved much during the last 30 years, much owing to the determined pressure by the environmental department of the municipality. Not only the environmental performance has seen its improvements, also the business structure of the city has changed, replacing a diverse range of small and medium size enterprisers (SMEs) for a limited number of large employers (Mirata & Emtairah 2004).

Figure 4: The location of Landskrona in Southern Sweden (http://www.weather-forecast.com/locationmaps/Landskrona.jpg, 2007-08-23)

3.1 The Landskrona Industrial Symbiosis Programme

The case study of this paper, the Landskrona Industrial Symbiosis Programme is a network project where possibilities have been found to reduce the mass of residues and an implementation has been made of the most efficient processes within different companies (Fundación Entorno). The official Landskrona Industrial Symbiosis Programme, financed by the Swedish Business Development Agency (NUTEK), was initiated in the spring of 2003 and involved over 20 companies and three public organisations. The participant companies belong to a diverse range of sectors including chemicals, waste management, metals processing and recycling, various types of printing and printed packaging, motor vehicle components, agricultural seeds, transport and logistics. The public organisations include those who manage

key infrastructure and support components such as district heating, environmental affairs and business development (Mirata & Emtairah 2004).

3.2 Activities that have been taken place

1) To know what parties in the Industrial Symbiosis programme was considered necessary, the key parties were identified. The parties were informed about the objectives of Landskrona Industrial Symbiosis Programme, the possible benefits, and the planned methodology for its development. Also the predictable difficulties were presented along with ideas how to overcome them.

2) Information was colleted for better understanding about the activities of the participating organisations and their resource needs and capacities were listed.

3) Possible complementarities among regional parties and potential areas for collaboration were identified. These were focused on the themes of energy, water, materials and chemicals, alternative fuels, logistics and managerial practices. Stakeholders in these areas were encouraged to organize themselves and further investigate the identified possibilities.

4) To facilitate interaction and communication between participating parties meetings were held approximately at six weekly intervals. Also plant tours, seminars and study tour were organized. Some of the connections in operation or with potential, that are associated with activities in Landskrona, are illustrated in Figure 5 (Mirata & Emtairah 2004).

3.3 Collective problem definition

Environmental challenges were discussed at a seminar where all programme participants were involved, at the early stages of the Landskrona Industrial Symbiosis Programme. The participants were presented and had the possibility to speak of challenges in a collective manner. The two main purposes this seminar served for was: (a) To raise the individual parties' awareness about the environmental challenges and benefits of collective action and more importantly, (b) to form the base for developing a shared understanding and collective commitment towards common goals. This seminar and the forthcoming activities helped the institutionalisation of an alternative way of addressing environmental challenges, to make the companies explore the means of dealing with these issues in a collective manner. The value of working together in environmental field has gradually been appreciated by the individual parties. Followed by this, more specific areas of concern were identified, and companies were encouraged to take part in the discussions about issues such as energy, waste materials and chemicals, alternative fuels, transportation, water and environmental management. This in turn

helped the companies to search solutions to their immediate environmental concerns. As a result, sub-groups of companies working on different themes were set up. Within these groups more concrete improvement possibilities were evaluated regarding their techno-economic and organisational feasibilities, as an initial step in the formation of an innovation network (Mirata & Emtairah 2004).

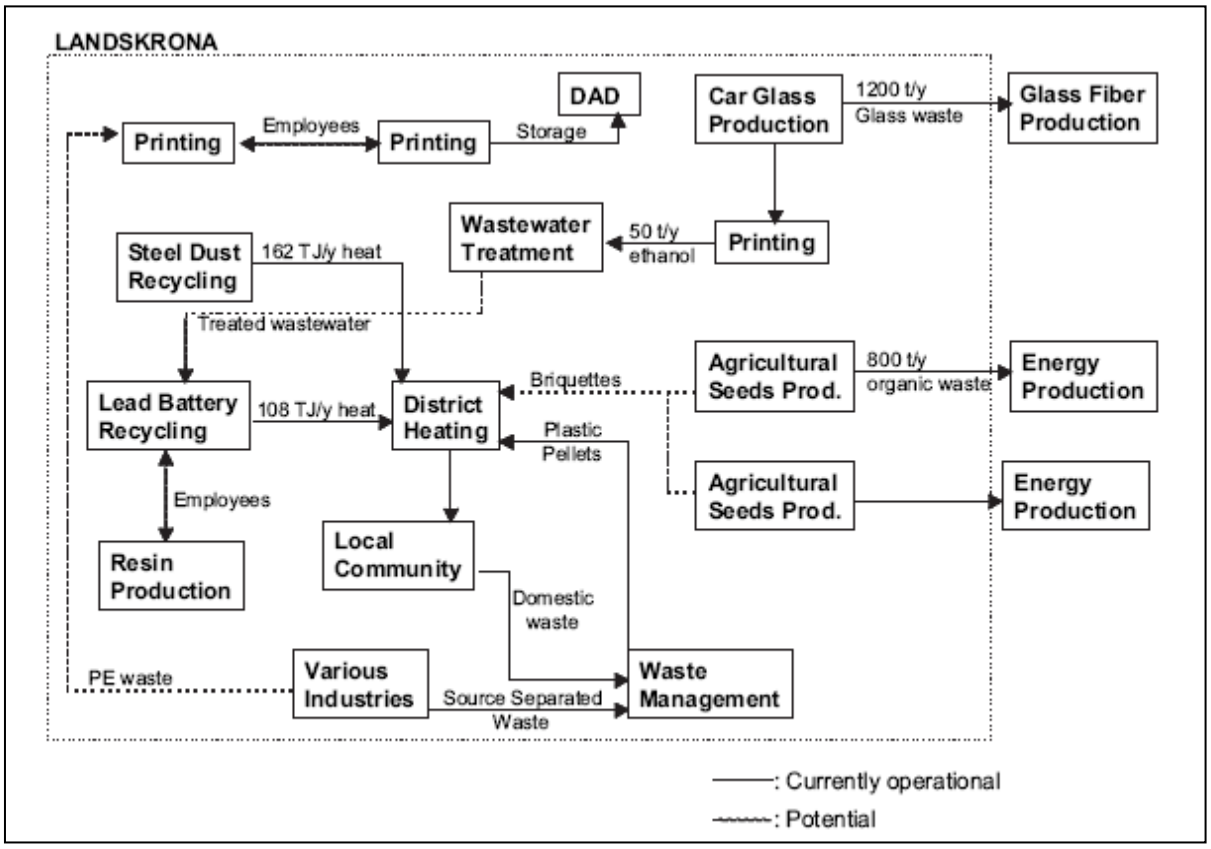

Figure 5: Existing and potential connections associated with activities in and around Landskrona (Mirata & Emtairah 2004)

4. Conclusions

There is a growing interest for the development of Industrial Symbiosis networks at local and regional levels. They are being promoted on the statement that more environmental improvements can be made if actions are pursued through synergies at the borders of each division than if pursued by individual units alone (Mirata & Emtairah 2004). It is important to admit that the knowledge about the innovation effects of Industrial Symbiosis network is still at an early stage of development. The results from Landskrona cannot be generalised. Variation in the Industrial Symbiosis programmes and how they are implemented together with variations in local or regional baseline circumstances influence such effects. Further research into Industrial Symbiosis networks and the effects is needed, also in a comparative way with other policy mechanisms that are designed for the stimulation of environmental innovation capacity locally or regionally (ibid.).

All the three types of benefits (social, ecological and economical) are linked together but the following categorization has been made to give an overview.

4.1 Social benefits

Industrial Symbiosis networks contribute to regional innovative capacity in general by means of attractive inter-organisational collaboration and learning, which is considered central in the functioning of regional innovation. The activities that are important for the innovation process are collective problem formulation and definition, search at the inter-sectored interfaces and inter-organisational collaboration and learning (Mirata & Emtairah 2004). Social benefits are the generation of new employment and raising the quality of existing jobs by creating cleaner, safer, natural and working environment. The work in Landskrona clearly demonstrates that there are considerable potentials that can be gained through collaboration on areas such as environmental management, transport and logistics and personnel exchange (ibid.). These kind of programmes also make important contributions to other significant developments, including regional *awareness raising*, *capacity building* and *learning*. Collectively these help the establishment of an institutional foundation upon which profound developments with solid sustainability contributions could be built (Mirata 2005).

4.2 Ecological benefits

The broader benefits occur through the contribution to environmental innovation activities in the local or regional context. Industrial Symbiosis networks bring into line innovation activities with the search for environmental improvements (Mirata & Emtairah 2004). Through the establishment of symbiotic connections M. Mirata (2005) has observed the following effects:

- A reduction of virgin materials as resource inputs.
- A reduction of pollution.
- A decrease in energy use due to increase in systemic energy efficiency.
- A reduction of waste products that require disposal The indirect benefit is the prevention of disposal related problems.

4.3 Financial benefits

In Landskrona, the dangerous waste, the emissions, and the landfill-waste has been reduced with a gain (an economical return) of 50%, in most of the cases within one year (Fundación Entorno). The financial benefits have to be counted during a longer period of time since the immediate impact is a raise of cost when system changes are made, but on the long run there will be a gain. The benefits also emerge from reductions in the resource input costs in production and from the generation of additional income due to higher values of by-product and waste streams. Also the types of process outputs with market value can be increased (Mirata 2005). The business benefits are noticed through an improved relationship with external parties, development of a green image, new products and new markets.

4.4 Barriers and solutions

Industrial Symbiosis faces a number of barriers where one of them is the limited evaluation of the complete costs and benefits of Industrial Symbiosis to both the individual participants and at the project level (Kuru et al 2005). The development of Industrial Symbiosis networks can be time consuming and expensive. Given this, it is important to provide a complete list of benefits that can be brought about with Industrial Symbiosis. This requires going beyond exclusively reporting on the number of synergies discovered and/or implemented and the resource savings they provide in the short and intermediate term (Mirata & Emtairah 2004). The innovation effects of Industrial Symbiosis are linked to benefits that can be maintained over long periods of time. The number of the effects and the conventional development of the region must

be elevated, to reduce the risk of regional parties losing their interest in Industrial Symbiosis networks.

Within the Landskrona Industrial Symbiosis programme, interviews were made with company managers six months after the initiation. Many of the managers expressed that being part of the network had helped them with valuable ideas on alternative ways of tackling their current environmental concerns and that they now expected the same for their potential future problems. They also valued the support the network enabled for the implementation of identified solutions. The stability of interactions and the diversity of actors is an important aspect, and adding different types of organisations, collaborating balances in local organisations needs and capacities rise (ibid.).

4.5 Further investigation

Suggestions that could guide for further investigation of Industrial Symbiosis programmes according to M. Mirata (2005) at IIIEE, are summarised in Table 2 as they are presented in his Doctoral Dissertation.

Domain targeted	Recommendations
IS practitioners	Give priority to human and organisational dimensions;
	Help establish common objectives that are shared, understood, and committed to;
	Search for developments within a diverse range of areas;
	Plan for the longer time;
	Monitor and communicate progress regarding awareness raising, capacity building, and learning;
	Be attentive to immediate business interests but do not lose sight of longer term sustainability vision;
	Engage a diverse range of actors in the developments, including those external to the regions;
IS scholars	Further concentrate on case studies and rely more on action research approaches;
	Investigate the sustainability performance of IS networks within wider geographic and temporal time scales;
	Investigate the importance of integrative application of strategies fostered by IE;
	Further investigate the potential of permitting procedures in IS developments;
	Include and develop social considerations in IS and IE developments;
Policy makers	Give more emphasis to regulatory reforms that deter the reliance on non-renewable resources and linear resource flows;
	Supplement national environmental improvement targets with regional targets;
Regional governance	Increase the weight given to environmental and social dimension of development;
	Explore means of public–private collaboration that can assist the developments of more sustainable systems.

Table 2: Summary of research inputs to different domains (after Mirata 2005)

References

Brundtland, G. H. (editor) (1987), *Our Common Future, the World Commission on Environment and Development*, Oxford, Oxford University Press, England

Fundación Entorno, undated, *La Gestión Sostenible en los Polígonos Industriales Una aplicación de la Ecología Industrial*, Fundación Entorno, Spain

Goodland, R., Daly, H., (1996) Environmental Sustainability: Universal and Non-Negotiable, *Ecolocical Applications*, vol. 6 (4) pp. 1002-1017

Kuru, B., Altham, W., van Berkel, R. (2005) *Triple Bottom Line Accounting Applied for Industrial Symbiosis*, paper for 4th ALCAS Conference in Sydney 2005, Australia

Mirata, M. (2005) *Industrial Symbiosis A tool for more sustainable regions?*, Doctoral Dissertation, The International Institute for Industrial Environmental Economics, Lund University, Sweden

Mirata, M., Emtairah, T. (2004) Industrial symbiosis networks and the contribution to environmental innovation: The case of the Landskrona industrial symbiosis programme, *Journal of Cleaner Production*, vol. 13 (2005) pp. 993-1002

Salmi, O. (2006) Eco-efficiency and industrial symbiosis e a counterfactual analysis of a mining community, *Journal of Cleaner Production*, vol. 15 (2007) pp. 1696-1705

Söderqvist, T., Hammer, M. & Gren, I-M. (2004), *Samverkan för Människa och Natur*, Lund, Studentlitteratur, Sweden

Van Beers, D. (2006) Capturing Regional Synergies in the Kwinana Industrial Area 2006 Status Report, Centre of Excellence in Cleaner Production Curtin University of Technology, Australia